Frank Leitz *has 42 years of experience in the field of desalination and water treatment. This comprises performance, supervision and monitoring of research; proposal evaluation and selection of research projects; equipment and component design; field testing; economic application studies; procurement; and equipment shakedown. It includes specialized experience with the processes of reverse osmosis and electrodialysis. Frank's experience includes 13 years in private industry with a major manufacturer of desalination equipment; 29 years with the federal government working on all aspects of desalination plants, and treatment of acid mine drainage; three years in Saudi Arabia working with the US-Saudi Joint Commission, located in Riyadh, as Research Coordinator and as Team Leader working primarily on establishment of the desalination Research, Development and Training Center in Al Jubail; and 10 years as member of the Editorial Board of Desalination Journal. Frank received B.S., M.S., and The Chemical Engineer degrees from M.I.T. He has more than 60 publications in desalination, water treatment, mass transfer, electrochemical processes, and computer simulations. Frank also has four patents on membranes and electrochemical cells.*

NATIONAL DESALINATION EFFORTS

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Thank you, Bobby, for that introduction. The title of my presentation is a little grander than my talk. The talk really is about the national desalination effort viewed from a Reclamation perspective. There are other agencies in the government that work on different aspects of desalination and I am not going to cover their efforts. On a biographical note, I spent a number of years working for a desalination company before I came to the government and I suspect that I was working on desalination before some of the members of this audience were born.

To begin, I'll give you an outline of my talk: I will start with a few comments on national needs, provide the status of the desalination effort as we see it, describe some of Reclamation's current activities and, finally, list some places where you can get information.

National Needs

A number of people at this meeting have already mentioned drought. Figure 1 shows drought conditions as of January this year. The darker colors, the red and the browns, represent the really bad areas and they seem to cover most of New Mexico. Personally, I had not appreciated how bad things were until I drove down here and noticed by the side of the road a couple of yellow and black diamond shaped signs that said

"Watch for water." Now, I did not see any but I presume that if I had I was supposed to dial 911 or something.

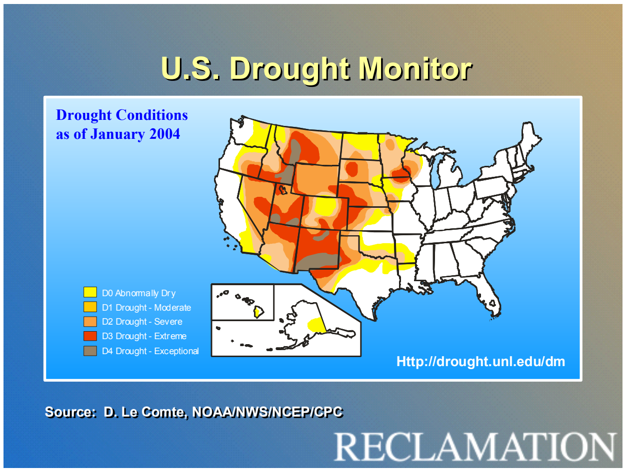

Figure 1.

Along with the drought, which hopefully will be over one of these days, we have long-term trends. One of those is population growth and the resulting increased need for water. The population of the 17 western states in 1902 was 11 million. I am not sure why someone picked 1902 except that that was the year that the U.S. Reclamation Service was founded. The 17 western states are basically Reclamation's area of concern. In 1990, those states had a population of 76 million, and in 2000, 91 million. It's no surprise that in the future, it is going to get more crowded here.

Between the years 2000 and 2025, the population of this area is expected to increase from 91 million to 126 million persons. Water withdrawals are predicted to increase from 91 million acre-feet to 284 million acre-feet. This represents an increase of 89 million acre-feet that must come from somewhere.

Where is this water going to come from? We have identified five possibilities that we are looking at, one of which, desalination, is what I will talk about today. The other possibilities are reuse, transfers, water conservation, and other new sources of water.

Status of Desalination

If I could only get two points across to you today, the first one would be that desalination is here and now. Figure 2 is a picture of the worldwide growth of the use of desalination, both curves of which are at about 3,000 million gallons per day. Don't ask why desalination plant capacities are expressed in millions of gallons instead of acre-feet; it's just that way. Water people generate this state of confusion to keep everyone on their toes.

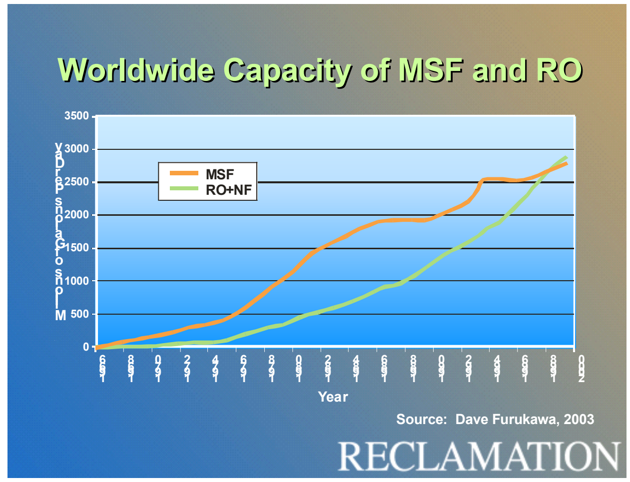

Figure 2.

Both thermal processes and membrane processes in the year 2000 were running about 3,000 millions of gallons a day cumulative capacity. This is probably divided among something like 10,000 different desalination facilities of one sort or another.

For those of you who have not seen a picture of a big desalination plant, Figure 3 is a shot of the Tampa Bay, Florida plant. To give you some scale, note the ordinary-sized automobiles toward the bottom left; you'll get the idea that this is a fairly large facility.

Figure 3.

Figure 4 shows where desalination plants are located in the United States. According to the IDA 2002 Worldwide Desalination Plants Inventory Report No. 17, about 2000 plants with a product capacity of over 150,000 gallons per day were scattered around the U.S., representing municipal, industrial, and pure water plants. Notice that the states with the largest accumulation are California, Texas, and Florida with over 100 plants per state. Only a couple of states in the U.S. do not have an identified desalination plant in this list. This report lists 20 plants in New Mexico.

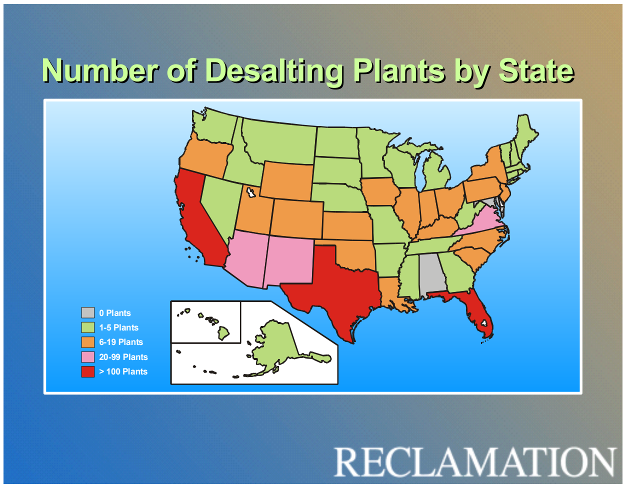

Figure 4.

Figure 5 shows locations for proposed desalination plants in the United States. One cannot miss the fact that the largest single cluster is around Los Angeles.

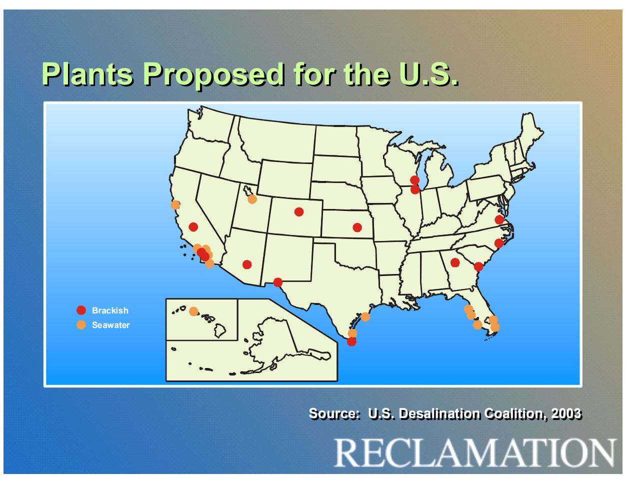

Figure 5.

The second point I want to get across is that desalination prices have gotten to the point where they are reasonable – not cheap, but reasonable. On Figure 6, I have used figures for seawater desalination although I recognize that New Mexico is not going to benefit from that in a big hurry, but these are a good representation of the cost trend. Please notice these are specific plants. They are fairly large seawater plants starting with the 1991 Santa Barbara plant. At that time, the cost of desalinating 1,000 gallons of seawater was almost $6.00. Over the next decade, cost has gone down to about $2.00 per 1000 gallons in Ashkelon, Israel. In case you wondering about the validity of these costs, most of these are plants built, owned, and operated not by a municipality, but by a private entity that runs the plant. These figures represent transfer costs to the water utility. So these are very definite, real costs. Whether the company makes money on the deal or not is something else again. At any rate, these are probably the best values we have for real costs and they show a very significant decrease over time. The source of these data is "Desalination Market Analysis 2001 – Today and Tomorrow" by Aqua Resources International, prepared for the Bureau of Reclamation, October 2001.

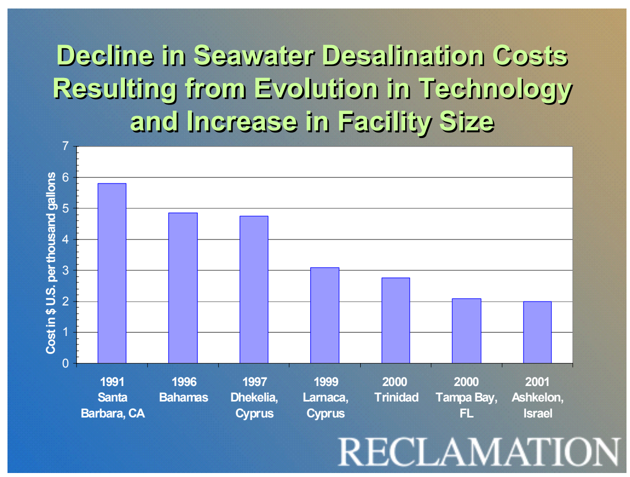

Figure 6.

With this in mind, let's look at a comparison of water costs. Sea water desalination costs $2.00 to 3.00/ 1000 gallons. This represents desalination costs and does not include distribution costs. Characteristically, brackish water desalination costs $1.00 to 2.00/1000 gallons, keeping in mind that costs are highly dependent on the chemical makeup of the brackish water. These again represent production costs.

Now what does water sell for? I looked up my local water utility in Evergreen, Colorado, and I am paying (in addition to connect charges) $2.50/1000 gallons for the first 9000 gallons used. Our water comes from a mountain lake. It is put through a microfiltration plant, stabilized and delivered. The cost increases with the next 5000 gallons used to $3.00/ 1000 gallons, and above 14,000 gallons, we pay $7.00/ 1000 gallons. A surtax in added when we are in a drought period. Thus, the production costs associated with desalination are not to far off from what some people currently are paying.

As for bottled water, I did a survey at my neighborhood market. The highest cost water I saw at the Kroger store near where I live was $8.56/ gallon—note this is per gallon, not per 1000 gallons. The cheapest bottled water they had sold for just under a dollar per gallon.

Current Reclamation Activities

The Bureau of Reclamation partners with many other entities and organizations including the WaterReuse Foundation, American Water Works Association Research Foundation, National Water Research Institute, Membrane Applied Science & Technology Center, Center for Biofilm Engineering, Middle East Desalination Research Center, Sandia National Laboratories, and the Interagency Consortium for Desalination and Membrane Separation Research. You can see that many folks are working on different aspects related to water desalination and we try to bring groups together to share problems and to avoid duplication of effort. Our research program at this point is largely guided by the desalination roadmap that you will hear about in the next presentation by Tom Hinkebein of Sandia National Laboratories.

One of our major efforts right now is getting the Tularosa Basin National Desalination Research Facility started. Your program cover has an architect's rendering of the facility.

It is reasonable to ask why we do research in desalination. We want to create options for water planners and water supply agencies. It seems appropriate for the government to share in the risk in some of the R&D investments. You heard Professor Tarquin talk earlier about the work he is doing on lime treatment. Some of the avenues he's gone up make sense and some efforts work very well. We are willing to share some of the risk inherent in research. We want to show how new technologies and practices can be made sustainable. We need to provide information on how these things work. And we want to create confidence so that a design engineer can go in, design a plan, and expect it to work reasonably well.

Our Desalination and Water Purification R&D Program is authorized by Public Law 104-298. You can look it up on the internet. It is the so-called "Simon Act." Senator Simon was a fairly far-sighted person whom, unfortunately, we no longer have with us. The Program's primary goals are to increase the nation's usable water supply; to develop and demonstrate the effective desalination and water treatment technologies; and to lower the costs of desalination technologies and related systems. We do not make any water with desalination, we make water that was unusable into usable water.

This Program is national in scope, unlike Reclamation's other efforts that are limited to the 17 western states. This is a national program with a strong nationwide constituency and we do applied research. The "applied" probably should be underlined. We are not really into basic research that somebody might use 20 years from now. We want to support research that somebody can take out into the street in a few years. The projects are cost shared, they are competitive, merit reviewed, and we constantly look at the "value" of the project.

I want to go quickly through some of the programs on which we are currently working. A gentleman earlier asked about oil fouling. Yale University is studying cleaning of fouled membranes. A foulant is a material that collects on a membrane surface and slows down passage of water through the membrane. Colloidal material is very finely divided particles that make water turbid or cloudy. Organic foulants come from decay of vegetative matter and frequently give color to natural waters. Scaling results from exceeding the solubility of salts like calcium carbonate and calcium sulfate. Biofouling results when bacteria settle on a surface and make themselves at home. All of these have affected membrane plants at one time or another and each may require a different method of removal.

Montgomery-Watson-Harza is a company working on removing perchlorate. This is a relatively new contaminant that people have started to worry about. It presumably has some undesirable health effects.

The Dow Chemical Company is looking at the possibility of using large diameter membranes. The standard conventional size for big plants is an 8-inch diameter element that is 40 inches long. A consortium under the leadership of Dow is looking at much larger membranes, 16-18 inches. They are looking ahead at what process simplification we have if we go to much bigger elements instead of the relatively small ones.

The Texas Water Development Board is just completing a study on using oil fields for concentrate disposal. A number of non-technical, institutional and permitting problems will need to be resolved.

Finally, a Professor at the University of Colorado is looking at taking pilot plant information or smaller bench-scale information and conducting plant-scale engineering with it. It will be interesting to see his results.

Our FY-03 pilot projects include dewvaporation, a process we are testing in Phoenix. It is a distillation process but it is a low temperature process and hopefully it will be able to use waste heat to further concentrate and come up with possibly either dry or solid material. Corollo Engineers is investigating river bank filtration as a pretreatment process. Another pilot project is being conducted by Novaflux Technologies. In the Novaflux process of cleaning membranes, a spray of fine water droplets shoots through a membrane element. The droplets may contain a detergent to aid cleaning. By dispersing water in air, a much higher shear force can be applied to the membrane surface than can be obtained with the conventional flowing of a stream of water through the element. They use a spray containing very small amounts of cleaning solution and the technique gets much higher shear force right at the membrane where you want to do your cleaning. Their preliminary investigations have been very successful.

FY-04 new research studies are in the process of being approved and are being processed through our acquisitions department so I can't name any names. However, the projects will include: membrane process work on produced waters; adding thermal processes to water treatment cost model; a study of the presence and removal of boron from water; a study of biofilm attachment to membranes; and a study to increase water recovery from high silica waters.

Produced waters are the great flushes of saline water that come out of gas wells when they are first developed. It is very expensive to get rid of this water because it usually contains a lot of salt and other contaminants. Right now the technique is to re-inject it. If we could treat this water at a reasonable cost, there is a chance of being able to put some of this water to useful purposes and to limit the amount of water we have to reinject.

We have a cost model that has been published. It is quite effective, however, it does not include thermal processes and that is something that we are working on right now.

The latest contaminant to come down the pike that people are worried about is boron. We have a group that will study not only the current distribution of boron in potential source waters but how effective some of our desalination processes are in removal of boron.

I mentioned biofilms earlier in terms of foulants. We are funding a study where we look at how biofilms attach themselves onto membranes with the intent of determining possible prevention and removal.

Finally, we are looking at increasing the water recovery from high silica waters. I am sure nobody who was here this morning could possibly guess when we would be doing that.

Figure 7 shows one of the new processes, Direct Contact Membrane Distillation (DCMD). This is a real quirky process, but it may turn out to be very useful. The diagram depicts the sides of a very narrow plastic tube; brine is put on one side and cold water on the other side. The water distills through the pores of the membrane. The appealing part of this process is that the path the water has to move along is in the order of a few microns.

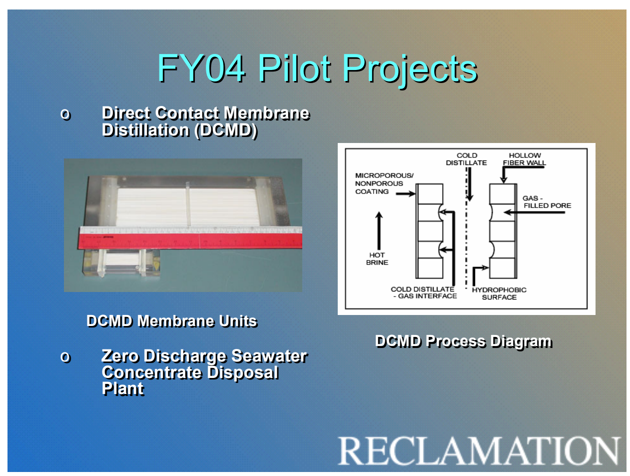

Figure 7.

We are also going to have a pilot plant on a zero discharge seawater concentrate disposal system. I always have reservations about "zero discharge" because zero is never quite zero. This project looks at how we can recover useful materials. A chemical engineering professor is working on the project and has come as close as I know of anybody to what really is important or possible from this sort of standard.

Available Information

Technology transfer is an important part of our program. It does not do us any good to have information and final reports if we cannot get them out to those who need the information. We have an active group that has developed and published a handbook for planners, Desalination Handbook for Planners. Our cost model, WTCost©, is a water treatment cost estimation program sponsored by AMTA. Desalnet is being marketed through the American Water Works Association and contains 50 years of a full-text desalination literature database. This represents some 1200 reports that were originally generated by the Office of Saline Water and are very difficult to find now. We have the databases on CD and they are all word searchable. Anybody who is trying to look through a bunch of reports for information can appreciate the virtue of the keyword search.

Finally, here are three websites that will give you access to our information:

- Program Homepage – www.usbr.gov/pmts/water/ desal.html
- Newsletter – www.usbr.gov/pmts/water/wfw.html
- Research Reports – www.usbr.gov/pmts/water/reports.html

My parting thought for today comes from Senator Simon: "If we spent five percent as much each year on desalination research as we spend on weapons research, we could enrich the lives of all humanity far beyond anything anyone has conceived."

To which I say, Amen.